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Modelling runoff and soil water content with the *DR2-2013© SAGA v1.1* model at catchment scale under Mediterranean conditions (NE Spain)

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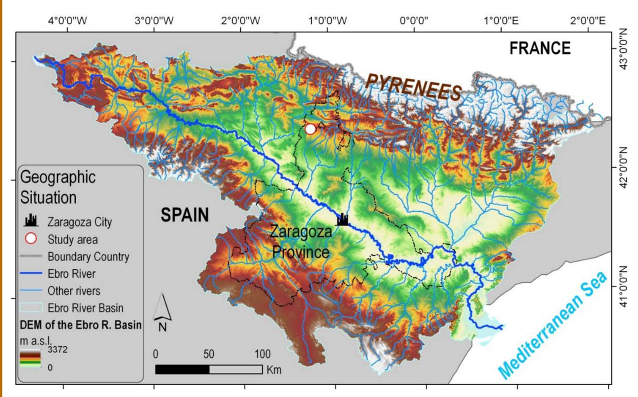
Introduction

Hydrological and soil erosion models allow mapping and quantifying spatially distributed rates of runoff depth and soil redistribution for different land uses, management and tillage practices and climatic scenarios. The different temporal and spatial [very small (< 1 km2), small (1–5 km2), medium (5–50 km2) and large catchments (50–1000 km2) or river basins (>1000 km2)] scales of simulations make model selection specific to each range of scales. Additionally, the spatial resolution of the inputs is in agreement with the size of the study area.

Objective: In this study, we run the GIS-based water balance DR2-2013© SAGA v1.1 model at monthly and annual scale.

Goals:
1) Effective Cumulative Runoff (*CQeff*, mm);
2) Soil water retention or Actual Available Water (*Waa*, mm);
3) Soil moisture status against water demand by evapotranspiration (*SMS*, seven categories).

Study Area



The Vanunchil stream catchment (23 km²) is located in the External Ranges of the Spanish Pre-Pyrenees and within the Ebro River Basin.

This catchment is an open hydrological system and it has a long history of human occupation, agricultural practices and water management.

Numerous man-made infrastructures appear (paved and unpaved trails, rock mounds in non-cultivated areas, disperse and small settlements, shallow and long drainage ditches, stone walls, small rock dams, fences and vegetation strips) that modify the runoff pathways.

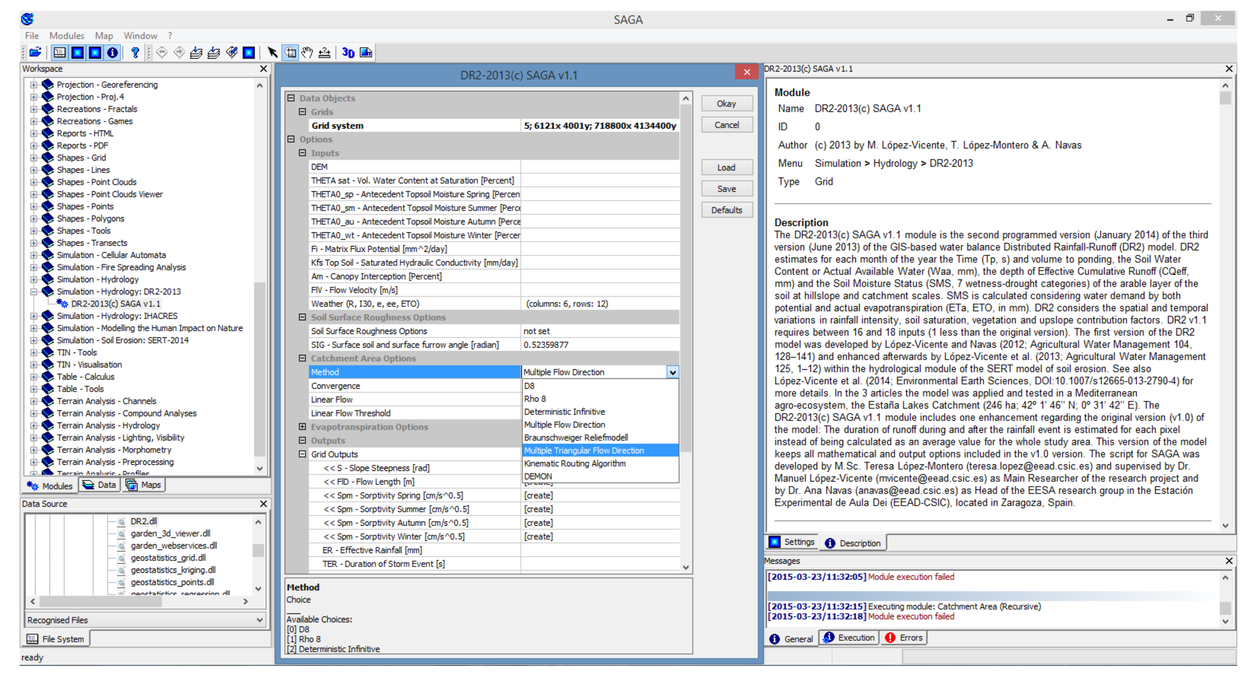
The climate is continental Mediterranean with two humid periods, one in spring and a second in autumn that summarizes 63% of the total annual precipitation.

Rain-fed cereal fields occupy one third of the catchment area, 1% corresponds to sealed soils, and the remaining area is covered with Mediterranean forest, scrubland, pine afforestation and meadow.

Parent material: Miocene sandstones and lutites and Holocene colluvial and alluvial deposits.

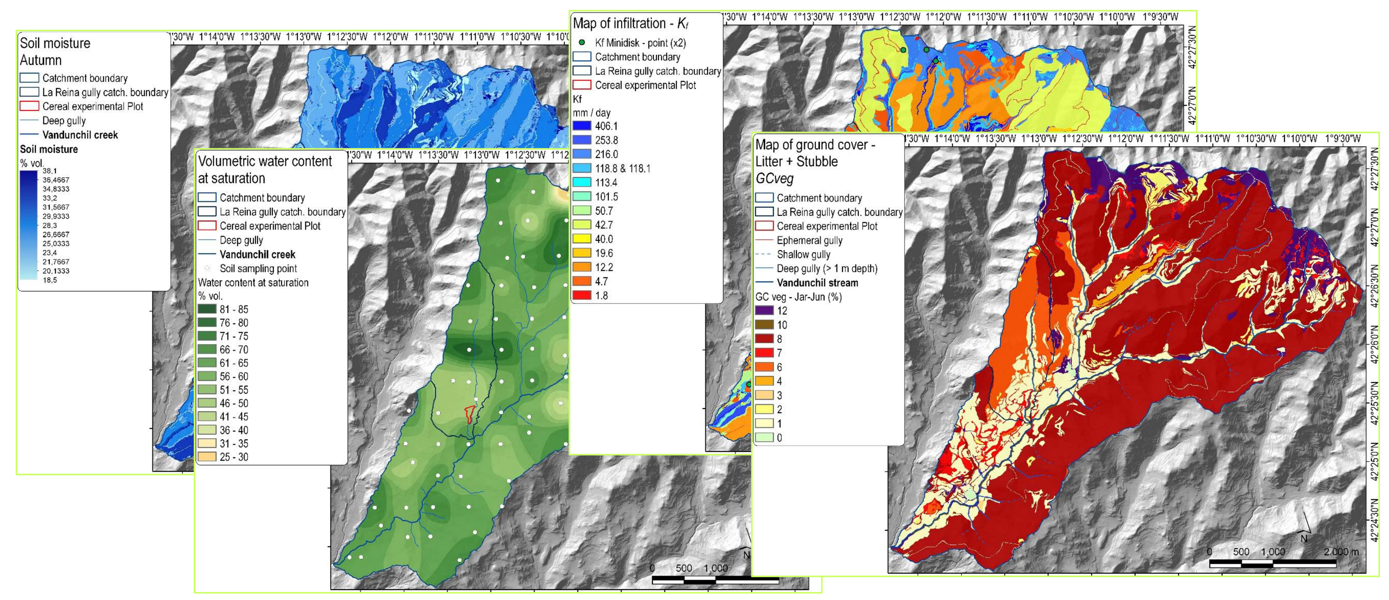
The *DR2-2013© SAGA v1.1* model & software

The GIS-based water balance ***DR2-2013*** model (López-Vicente *et al.*, 2014) is the third version of the ***DR2*** (Distributed Rainfall-Runoff) hydrological model (López-Vicente and Navas, 2012). It computes the depth of water stored and infiltrated in the soil and the runoff depth, considering spatial and temporal variations in rainfall intensity, soil saturation and upslope contributing factors.



Since October 2013 the executable file (DR2.dll) of the version 1.0 is available for free downloading (http://digital.csic.es/handle/10261/84613) and since January 2014 of the version 1.1 (http://digital.csic.es/handle/10261/93543) (http://www.eead.csic.es/web/guest/software).

- We created a synthetic weather station (WS) from the Caseda and Uncastillo WS. The average annual rainfall was 556 mm for the period 1992-2012 (21 years) with a strong inter-annual oscillation of 96% (from 393 mm in 2001 until 768 mm in 1997).
- All input maps are generated at 5 x 5 m of cell size (924,573 pixels per map) allowing sound parameterization.
- Simulation is run at monthly scale with average climatic values.

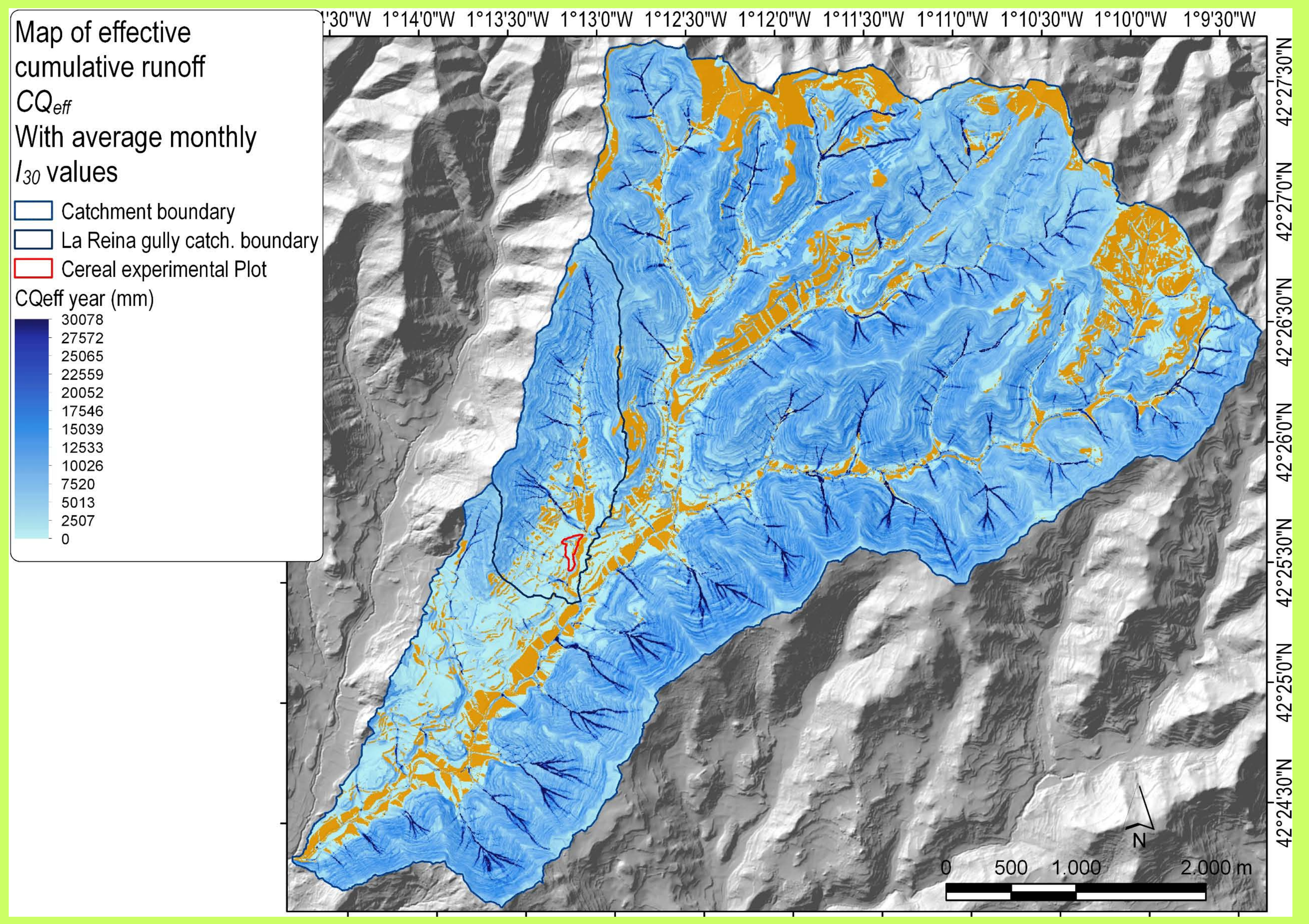


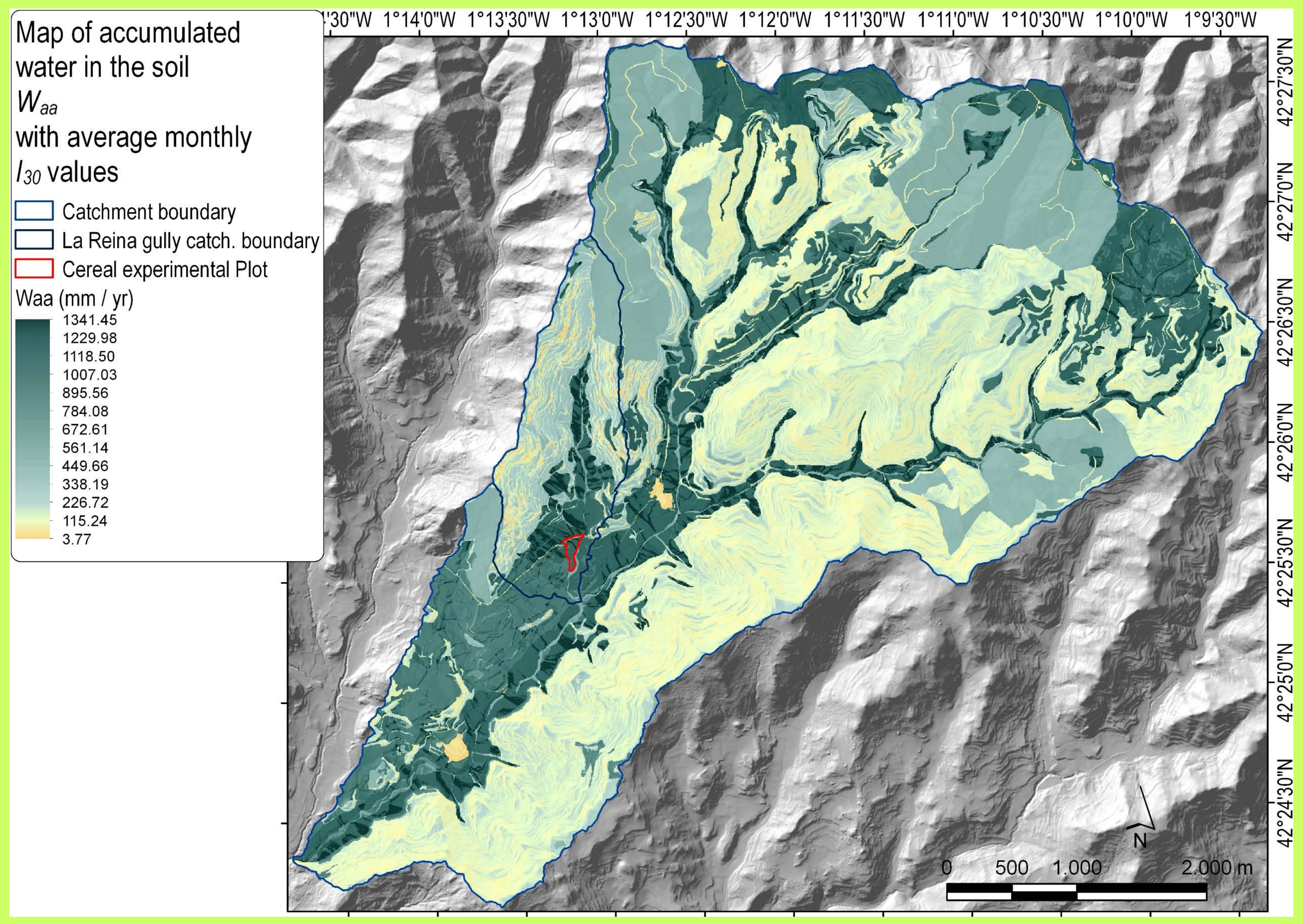
*Effective Runoff - **CQeff***

The effective rainfall that reaches the soils (after canopy interception and slope correction) was 85% on average from the total rainfall depth (556 mm yr–1) and the average initial runoff, before overland flow processes, was 320 mm yr–1.

The simulated effective runoff (CQeff) ranged from 0 until 29,960 mm yr–1 and the corresponding map showed the typical spatial pattern of overland flow pathways though numerous disruptions appeared along the hillslopes and the main streams due to the presence of LLEs.

The total depth of annual runoff corresponds to 37.8% of the total effective rainfall (TER) and 32.0% of the total rainfall depth (TR).





*Soil Water Retention - **Waa***

The remaining volume of water, the soil water content (Waa) associated with the runoff and rainfall events, meant 62.2% and 52.7% of the TER and TR, respectively.

1) Runoff

14. Stadistical Analysis - CQeff

	Month	Mean	Min	Max	Variance	Standard Deviation
1	January	10.545009	0.000000	2597.302979	936.321490	30.599371
2	February	8.653738	0.000000	2051.136963	586.943656	24.226920
3	March	12.059442	0.000000	2000.336304	665.400676	25.795362
4	April	18.879855	0.000000	3065.583496	1572.749896	39.657911
5	May	15.214390	0.000000	2533.718994	1072.341240	32.746622
6	June	11.239530	0.000000	1740.321533	540.255756	23.243402
7	July	8.354622	0.000000	1337.337891	302.741694	17.399474
8	August	9.467108	0.000000	1550.961060	405.241717	20.130616
9	September	17.383849	0.000000	2869.129150	1392.423024	37.315185
10	October	24.597847	0.000000	3623.394775	2383.404408	48.820123
11	November	16.406386	0.000000	2940.183594	1373.805760	37.064886
12	December	15.801231	0.000000	3768.645508	1982.111770	44.520914
13	Sum	168.603009	0.000000	30078.052246	13213.741087	381.520785
14	Annual Mean	14.050251	0.000000	2506.504354	1101.145091	31.793399

2) Soil water retention

28. Stadistical Analysis - Waa

	Month	Mean	Min	Max	Variance	Standard Deviation
1	January	18.464442	0.339195	109.065727	346.937277	18.626252
2	February	13.638954	0.150283	57.552414	203.045347	14.249398
3	March	13.092095	0.191356	103.192177	280.764982	16.756043
4	April	18.971606	0.366383	138.158554	652.730365	25.548588
5	May	17.150343	0.177249	143.639252	449.454561	21.200343
6	June	13.337320	0.045556	142.488678	219.907691	14.829285
7	July	9.351338	-125.434647	74.745285	170.521061	13.058371
8	August	10.108567	0.267093	82.662010	186.053156	13.640130
9	September	20.024930	0.091284	142.925598	707.407981	26.597142
10	October	24.767604	0.054053	196.112762	1166.423221	34.152939
11	November	19.997803	0.314676	149.646042	651.346100	25.521483
12	December	25.393000	0.277099	119.039162	721.399148	26.858875
13	Sum	204.298002	-123.160421	1459.227661	5755.990888	251.038851
14	Annual Mean	17.024834	-10.263368	121.602305	479.665907	20.919904

3) Soil moisture status

42. dr2-sms-table

	Month	Mean	Min	Max	Variance	Standard Deviation
1	January	0.684375	0.012572	4.042466	0.476614	0.690373
2	February	0.320464	0.003531	1.352265	0.112096	0.334807
3	March	0.172696	0.002524	1.361195	0.048853	0.221027
4	April	0.188753	0.003645	1.374575	0.064612	0.254190
5	May	0.133036	0.001375	1.114217	0.027044	0.164452
6	June	0.090401	0.000309	0.965796	0.010103	0.100514
7	July	0.047166	-0.632662	0.376997	0.004338	0.065863
8	August	0.057300	0.001514	0.468566	0.005978	0.077318
9	September	0.174062	0.000793	1.242345	0.053448	0.231189
10	October	0.300359	0.000656	2.378277	0.171542	0.414176
11	November	0.575145	0.009050	4.303884	0.538769	0.734009
12	December	0.936234	0.010217	4.388945	0.980655	0.990280

Conclusions

- The map of the Waa presented a different spatial pattern where the land uses play a more important role than the processes of cumulative overland flow.
- Significant variations in the monthly values of CQeff and Waa were described. This study proves the ability of the DR2-2013© SAGA v1.1 model to simulate the hydrological response of the soils at catchment scale.

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